POLLUTION PREVENTION AT LOS ALAMOS NATIONAL LABORATORY

Electronic Equipment Leaving Radiological Control Areas

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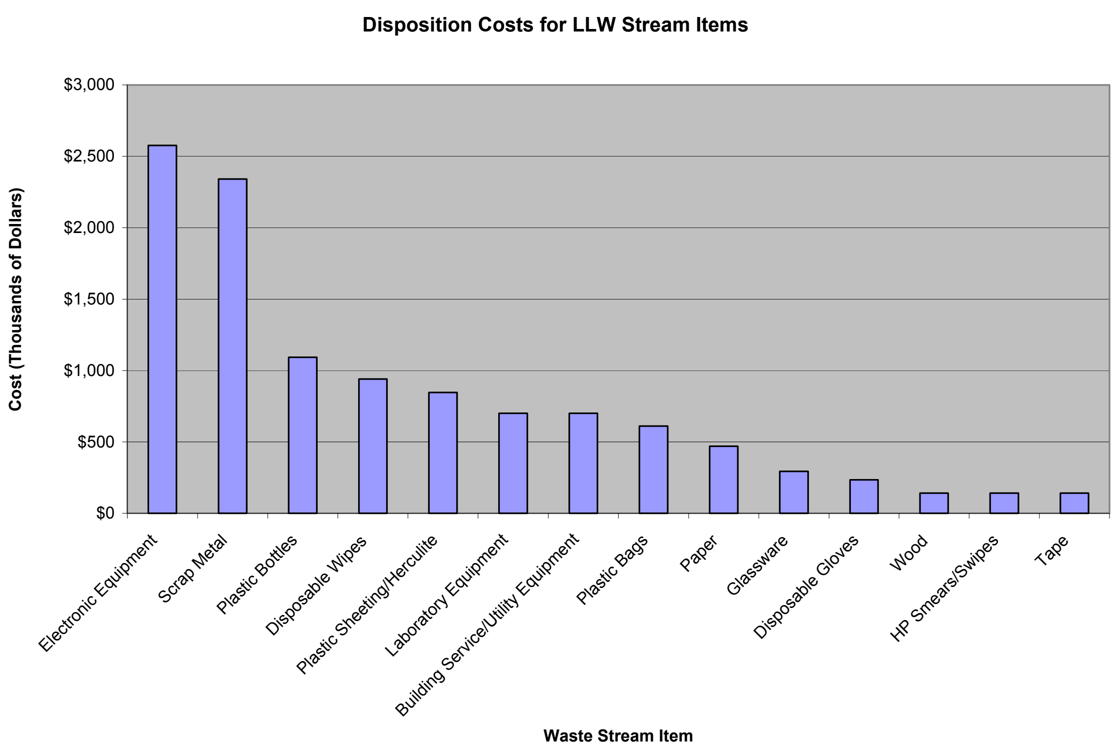
The Challenge

Production of electronic waste from Radiological Control Areas (RCAs) accounts for approximately 200 cu. meters of Low Level Waste (LLW) and Mixed Low Level Waste (MLLW) (1993). The cost to dispose of this waste stream was estimated to be $2,577,000 (See Attachment 1 and Figure 1). Perhaps much of this waste could be prevented by maintaining better control over this equipment or by other means. This paper will explore how a team was formed and how this team used the following tools to address issues involved in the unnecessary disposal of electronics equipment:

- Determine Opportunities in the current process using process maps
- Rank Ordering of the opportunities to improve the process using Pareto Analysis and activity-based costing
- Determine the root cause of the selected opportunity using a cause and effect (fishbone) diagram
- Pose a consensus problem statement for generator process alternative
- Generate process alternatives using a brainwriting tool
- Select an alternative using forced pairs comparison (bubble-up/bubble-down)
- Implement the selected alternative with a formal action plan

Figure 1



Green Zia Electronics Team

A multi-disciplinary team was formed to examine improvements that could be made to prevent electronic equipment from being disposed of as LLW. Participants on this team included people familiar with RCAs and electronic equipment use in these areas. The following individuals were members of the team:

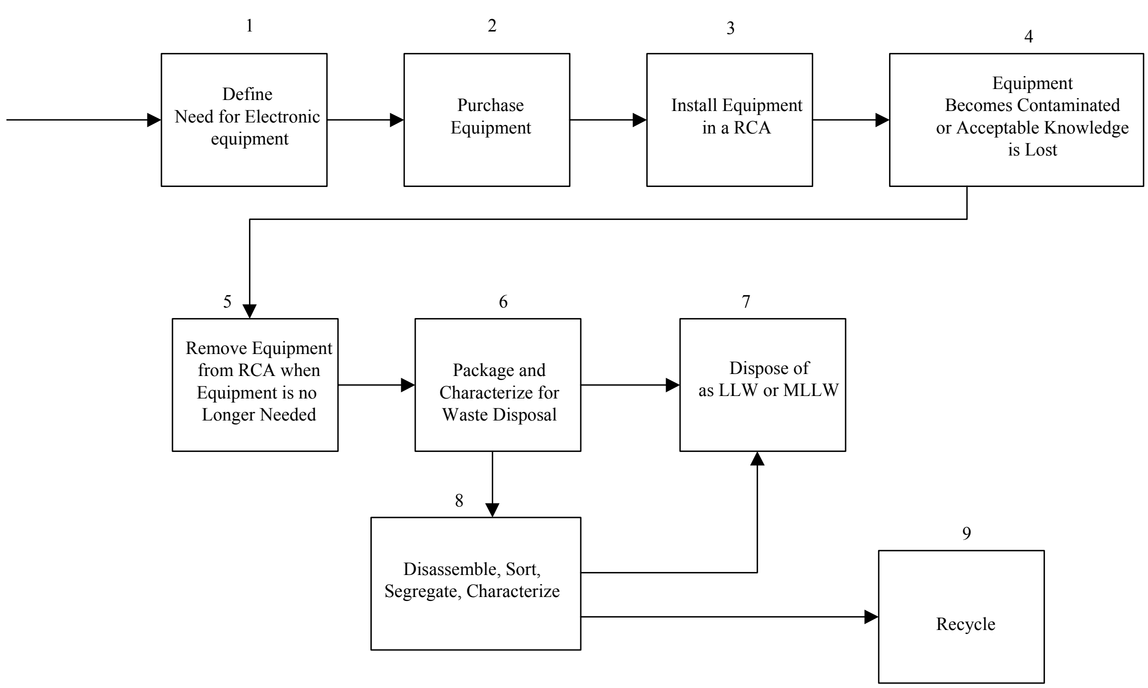
- Thomas Starke, Program Manager, Environmental Stewardship Office
- Myrna Romero, Project Leader, Decontamination Operations
- Egan McCormick, TA-55 Waste Management Coordinator
- Lorenzo Trujillo, CMR Waste Management Coordinator
- Allan Hoff, NMT-3 Test and Measurement Technician
- Bryan Carlson, MLLW and LLW Coordinator, Environmental Stewardship Office
- Roger Huchton, TRU Waste Coordinator, Environmental Stewardship Office
- Alicia Hale, Team Facilitator
- Robert Pojasek, Consultant

This team met on several occasions to complete the work on this project.

Process Characterization

The team prepared a process maps that depicts the entire life cycle associated with electronic equipment, from definition of need to ultimate disposal of the equipment at its end of life. This process map is depicted in Figure 2.

Figure 2



A need for the specific piece of electronic equipment if first identified (Step 1). After the need has been identified the equipment is purchased and installed inside of a RCA (Steps 2 and 3). After the equipment has been installed, the equipment either becomes radiologically contaminated or acceptable knowledge that the equipment was not contaminated is lost (Step 4). When the equipment is no longer needed, it is removed from the RCA and package and characterize for waste disposal (Steps 5 and 6). A this time, it is either disposed of as LLW or MLLW or sent to facility for disassembly, sorting, segregation, and characterization (Steps 7 and 8). Material that is found to be radiologically clean at the sorting and segregation facility are recycled (Step 9). Materials that are radiologically contaminated are disposed of as either LLW or MLLW.

Rank Ordering of Opportunities

Activities involved in the electronics equipment process are depicted in Table 1. For each activity, a cost was calculated.

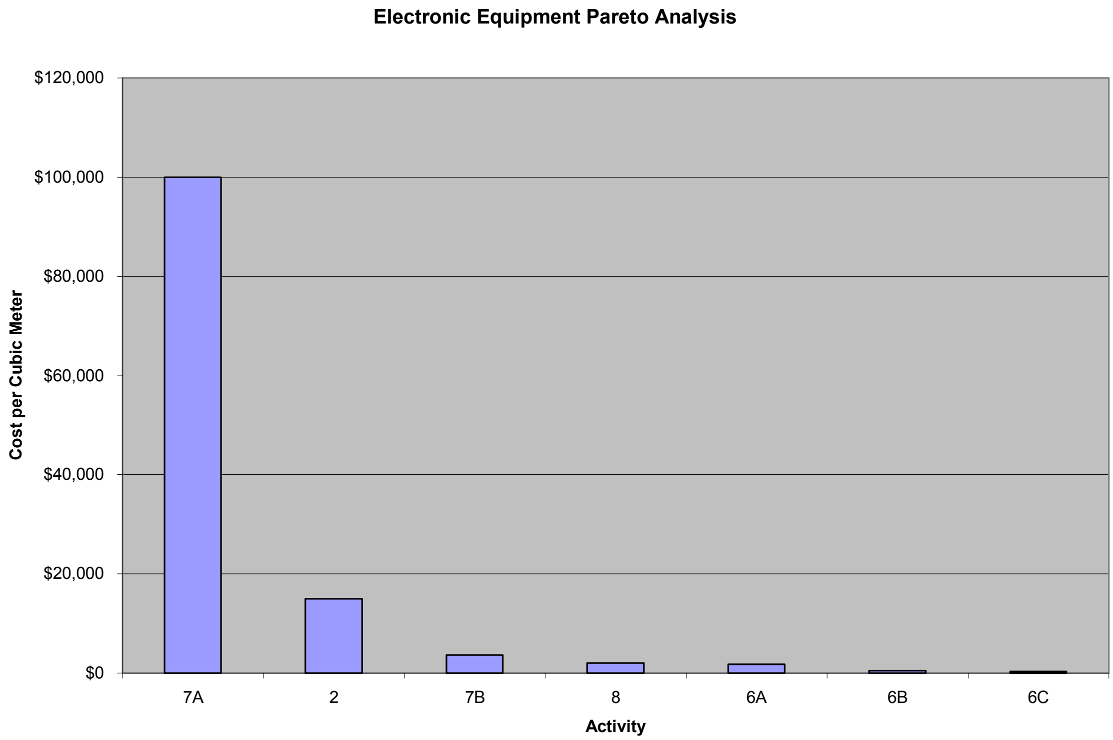
A Pareto Chart for these costs may be found in Figure 3. The results of this analysis clearly shows that the three most expensive activities are as follows: 1. Disposal of equipment as MLLW; 2. Purchase of the equipment; and 3. Disposal of equipment as LLW.

Table 1 – Activity-Based Costing

Activity #	Activity	Cost $/m^3
2	Purchase Equipment[1]	$15,000.00
6A	Package, Characterize, and Transport MLLW	$1,764.00
6B	Package, Characterize, and Transport LLW	$464.00
6C	Package, Characterize, and Transport to TA-50	$296.68
7A	Dispose of as MLLW	$100,000.00
7B	Dispose of as LLW	$3,668.00
8	Disassemble, Sort, Segregate, and Characterize	$2,000.00

[1]Note: Purchase of Equipment based on the cost and disposal volume of a typical personal computer system.

Figure 3 – Pareto Analysis



Root Cause Analysis and Statement of Problem

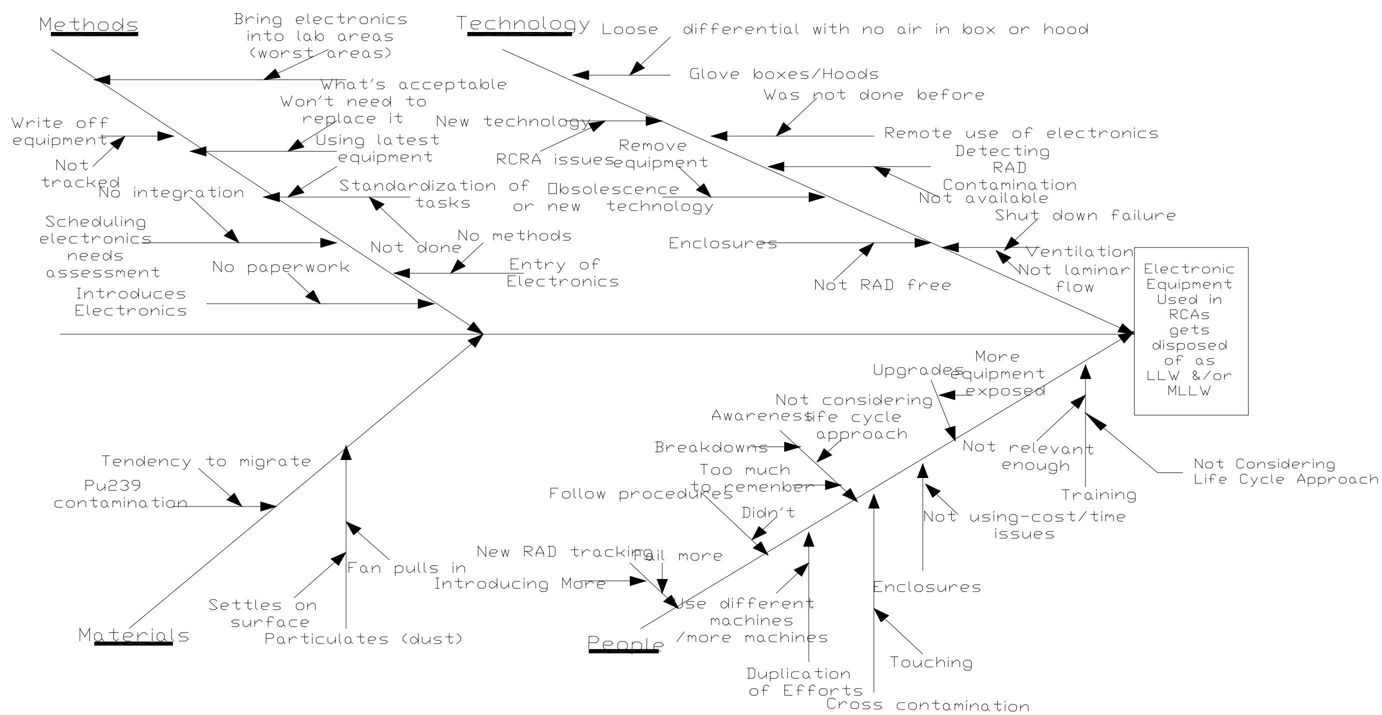
Team prepared a fishbone diagram (see Figure 4) for the problem of having to dispose of electronic equipment as a LLW or MLLW. Team members were requested to review the results of the root cause analysis and prepare a memorandum to the process owner that captured what each person thought were the major issues involved in the generation of this expensive waste stream. The memoranda were read aloud and the following consensus statement of problem was prepared:

Electronic equipment used in RCAs is currently being disposed of as LLW and/or MLLW. This is a significant problem because of the volume and costs associated with the management and disposal of this waste stream. There are at least four causes that contribute to this situation:

- *Increasing use of electronic equipment in RCAs*
- *Lack of adequate survey equipment to detect low level contamination at the current release criteria*
- *Lack of design longevity to keep equipment from going obsolete and requiring disposal*
- *Very low regulatory release criteria*

Current practice encourages the disposal of the electronic equipment instead of the use of programs to recycle electronics at the end-of-life in the RCA or the implementation of alternatives that prevent the generation of these expensive wastes.

Figure 4


Methods
Bring electronics into lab areas (worst areas)
What's acceptable
Won't need to replace it
Write off equipment
Not tracked
Using latest equipment
No integration
Standardization of tasks
Scheduling electronics needs assessment
Not done
No methods
No paperwork
Entry of Electronics
Introduces Electronics
Technology
Loose differential with no air in box or hood
Glove boxes/Hoods
Was not done before
New technology
Remote use of electronics
RCRA issues
Remove equipment
Detecting RAD Contamination
Not available
Obsolescence or new technology
Shut down failure
Enclosures
Ventilation
Not laminar flow
Not RAD free
Electronic Equipment Used in RCAs gets disposed of as LLW &/or MLLW
Materials
Tendency to migrate
Pu239 contamination
Fan pulls in
Settles on surface
Particulates (dust)
People
Upgrades
More equipment exposed
Not considering life cycle approach
Awareness
Breakdowns
Too much to remember
Follow procedures
Didn't
Not relevant enough
Training
Not Considering Life Cycle Approach
Not using-cost/time issues
New RAD tracking
Fail more
Introducing More
Use different machines /more machines
Enclosures
Duplication of Efforts
Touching
Cross contamination

Generating Process Alternatives

A brainwriting tool was used by the team to generate possible alternatives to the problem discussed above. The alternatives that resulted from this activity are as follows:

1. Improve employee awareness through training and procedure modification – "everything that goes into an RCA must come out"
2. Use remote control and monitoring in RCAs
3. Enclose electronic equipment to avoid contamination
4. Establish configuration control for electronic systems
5. Increase use of systems tools for local problem solving and decision making
6. Share more network computer stations – eliminate duplication of equipment
7. Share data acquisition between groups
8. Improve "acceptable knowledge" to prevent disposal as radioactive waste
9. Use a tracking system to account for equipment from the time that it comes into a facility to when it leaves the RCA (life cycle approach)
10. Establish electronics recycle capability
11. Encase all piping/valves to prevent releases of contaminants to room
12. Reduce the number of contamination incidents
13. Factor cost of disposal in purchase cost to drive purchase decisions (Life cycle costs)
14. Consider design longevity in approving equipment that can go into a RCA
15. Use strippable coatings to protect equipment and remove contamination
16. Use hermetically sealed electronics (e.g. keyboards and flat screen monitors)
17. Decontaminate electronics with vacuum systems
18. Improve characterization and detection technologies
19. Don't let people take electronics into worst areas – graded approach
20. Just don't allow electronics into RCAs
21. Buy "green" electronics (i.e. containing no RCRA materials)
22. Buy portable/miniature equipment to make more transportable
23. Implement proposed ANSI Standard N13.12 (increase release limit)
24. Appeal regulations (e.g. lead disposal) to U.S. EPA Office of Reinvention for change

Selecting an Alternative

The team used a force pair comparison (i.e. bubble-up/bubble-down) to select alternatives that should be implemented in the near term. In conducting this exercise, a number of the alternatives from the brainwriting exercise were combined with similar suggestions. The final ordering was reviewed by the group and is presented below:

1. Improve employee awareness (what goes into a RCA must come out possibly as MLLW or LLW) through training and enhanced procedures. The group leader at TA-55 has reaffirmed the need to keep materials free from contamination. This new awareness has been focused on low density wastes such as paper. It can be extended to electronics with a feeling for what this will cost the group. This is easy to implement.
2. Remote control and monitoring. This is an on-going effort when a new facility control system is put in place. It is typically done to facilitate safety monitoring. Needs to be expanded to other systems. This should be easy to implement.
3. Enclose electronic equipment to avoid contamination. When new equipment is purchased for the purpose of bringing it into a RCA, the owner should seek to enclose the equipment to

avoid the potential for contamination. Implement over time as new equipment is purchased. Related to alternative number 1 above.

4. Establish local control of electronic waste avoidance at each RCA in anticipation of the implementation of a charge back system (combining items 4 & 5 from brainwriting exercise).
5. Share computer stations located in RCAs to avoid bringing more electronic equipment into the system and similarly share data acquisition equipment between groups (combining items 6 & 7 from the brainwriting exercise). This will take more communication and cooperation between groups that use each RCA.
6. Improve “acceptable knowledge” of equipment used in RCAs by setting up a tracking system to be used in parallel with the property tracking systems that assigns and monitors “ownership” for every piece of equipment that enters a RCA (combining items 8 & 9 from brainwriting exercise). The issue of improving acceptable knowledge is on going. The use of a computerized tracking system for this purpose would need to be studied and funds would have to be set aside to implement and maintain this system. Right now the equipment that enters the RCA is “retired” from the property tracking system.
7. Establish a viable electronics recycle capability. Although this is not a prevention option per se, it is already being implemented to some extent to keep the volume of MLLW as low as possible.
8. Improve contamination control (combining items 11 & 12 from brainwriting exercise). Because this addresses safety issues, it is an on-going program. Need to determine how to influence the implementation of this program as it relates to potential contamination of electronic equipment.
9. When purchasing new equipment that will be used in RCAs, factor the cost of disposal (and other life cycle costs) into the cost of purchase to drive purchasing decisions that avoid the generation of MLLW. Consider the design longevity in approving the purchase of equipment that goes into a RCA so it will not need to be replaced soon. Equipment should be designed for upgrade within the RCA to prevent the introduction of new equipment (combining items 13 & 14 from the brainwriting exercise).
10. Find coating that can be used on non-powered equipment (low heat) that can be stripped off when the equipment is removed from the RCA, removing contamination, and keeping the equipment out of the MLLW stream. Some keyboards and flat screen monitors are hermetically sealed and may represent equipment that can fit into this category (combining items 15 & 16 from the brainwriting exercise).
11. Improve decontamination methodologies to keep equipment from being disposed of as MLLW and improve characterization technologies (combining items 17 & 18 from the brainwriting exercise).
12. Seek to keep people from freely introducing electronics into the high contamination risk areas of the RCAs and keep track of who owns the equipment that is brought into these areas (what gets monitored gets managed) (combining items 19 & 20 from brainwriting exercise). The second part of this alternative may be related to item 9 from the brainwriting exercise and include in item 6 above.
13. Encourage the purchase of “green” electronics that will not need to be handled as RCRA characteristic waste – a designation that shifts the waste from a LLW to a MLLW when contamination occurs.
14. Buy portable/miniature equipment that makes it easier to transport in and out of RCAs to avoid the “acceptable knowledge” problem. The thought is that when the equipment is under the firm control of a person, there will be knowledge of incidents that could lead to contamination.
15. Implement proposed ANSI Standard N13.12 that increases the release limits for contamination. This is the trigger point to determine if a waste is designated as LLW or MLLW.

16. Appeal the designation of electronics as MLLW with the U.S. EPA's Office of Reinvention. The thought is that the electronics should be disposed of as LLW regardless of the fact that it contains RCRA hazardous materials. The reasoning is that the LLW disposal site, which is designed to protect the public from radioactive contamination, is also adequate to protect the public from the hazardous materials present in electronic equipment. This would totally avoid the entire MLLW issue as related to electronic equipment.

Implementing the Alternative

Funding is not available from the Nuclear Weapons Program to implement the preferred alternatives at this time. However, the LANL Environmental Stewardship Office (ESO) is seeking funding to develop and implement an action plan.

Benefits

The use of the Green Zia tools heightened awareness that a relatively low volume LLW stream had such a marked financial impact. Typically pollution prevention programs target the higher volume waste streams. It is possible to prevent the introduction of electronic equipment into the MLLW. The ESO at the Laboratory has taken actions in FY 1999 to promote pollution prevention in this very expensive waste stream. This should encourage the people who participated in this effort to integrate these pollution prevention efforts in their FY2000 program. ESO will track the success of this effort in the FY2000 program.

ATTACHMENT 1
Supplemental Activity Based Costing Information

Road maps were prepared for the various processes contributing to the Low Level Waste (LLW) streams at Los Alamos National Laboratory (LANL). These waste streams are generated because materials and equipment are brought into radiological control areas (RCAs), radiologically contaminated, and then removed. Mixed low level waste (MLLW) refers to material and equipment that is also contaminated with a substance controlled under the Resource Conservation and Recovery Act (RCRA). In some cases, the MLLW is considered to be a subset of the LLW stream. The LLW road map is presented in Figure 1. A Pareto distribution of the LLW streams is presented in Figure 2. This distribution is presented by volume. An effort was made to convert this Pareto distribution to a monetary basis in order to identify the most expensive LLW stream.

Figure 1

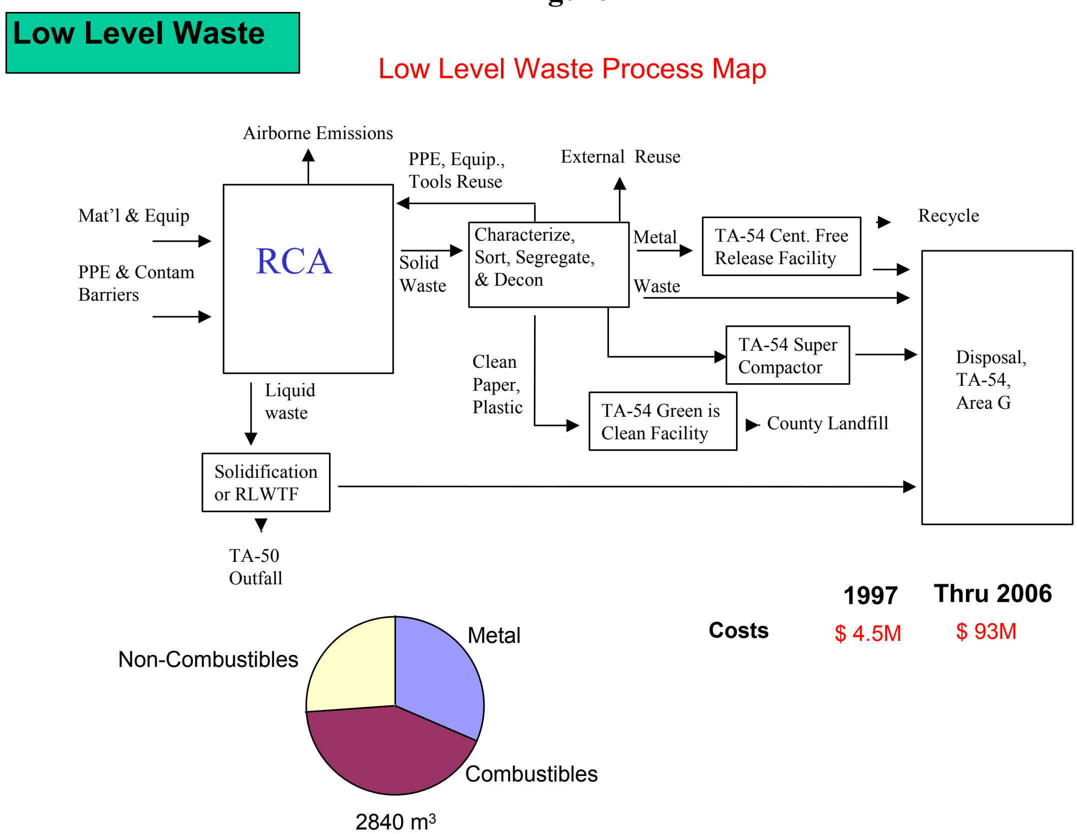
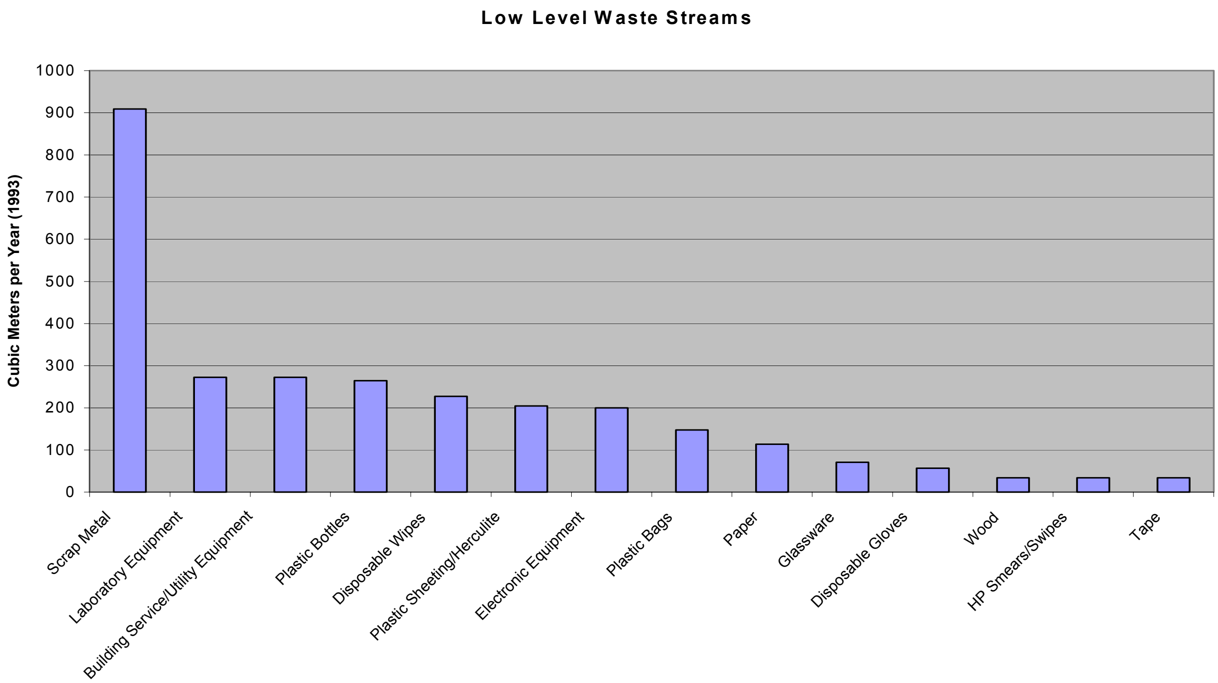


Figure 2



Activity-based costs for the LLW stream were determined. The costs were driven primarily by the pathway for disposal of the radiologically-contaminated material. Three major pathways are currently utilized:

1. Burial as LLW
2. Sorting, Segregation, and Recycling (S/S/R)
3. Disassembly, Sorting, Segregation, and Recycling of Electronic Equipment (DSSR).

All waste leaving a RCA at LANL is considered radioactive unless radiological surveys indicate that the levels of radioactivity meet the criteria established for release to disposal as sanitary solid waste or recycle. It is estimated that 50% of the waste at the laboratory buried as LLW could be either released for disposal as a sanitary solid waste or recycled if the appropriate release criteria and technology exists. At the present time, release criteria only exist for scrap metal and similar items that have the potential to be surface contaminated. No release criteria have been established for volume-contaminated material. S/S/R refers to the process typically used to determine if scrap metal items meet the release criteria and can be recycled. DSSR refers to an activity typically associated with electronic equipment. Electronic equipment must be disassembled before sorting, segregation, and recycling activities can be performed. Many components that cannot be recycled must be disposed of as MLLW because they contain RCRA regulated components such as lead solder. The RCRA component must be accounted for in the activity-based cost. Tables 1 and 2 depict the costs associated with MLLW and LLW disposal.

Because the costs in these tables are volume dependent, they are calculated on a cost per unit volume basis. Of the materials covered in the road map, approximately 50% can be released for recycling after the equipment is disassembled and a radiological survey is performed.

Table 1: LLW Disposal Cost

Task	**Hours**	**Labor Cost ($/hr)**	**Volume (m^3)**	**Cost/m^3**
Prepare Waste Profile Form	80	$75.00	50	$120.00
Characterize Waste	8	$75.00	2.7	$222.22
Prepare CWDR	8	$75.00	30	$20.00
Survey Waste Shipment	4	$75.00	30	$10.00
Load Waste Shipment	4	$75.00	30	$10.00
Transport Waste Shipment	2	$75.00	30	$5.00
SubTotal				$387.22
Management Overview (10%)				$38.72
ES&H Overview (10%)				$38.72
Sub Total				$464.66
LLW Management Cost				$3668.00
Total				$4132.66

Table 2: MLLW Disposal Cost

Task	**Hours**	**Labor Cost ($/hr)**	**Volume (m^3)**	**Cost/m^3**
Prepare Waste Profile Form	80	$75.00	10	$600.00
Characterize Waste	8	$75.00	1	$600.00
Prepare CWDR	8	$75.00	5	$120.00
Survey Waste Shipment	4	$75.00	5	$60.00
Load Waste Shipment	4	$75.00	5	$60.00
Transport Waste Shipment	2	$75.00	5	$30.00
SubTotal				$1470.00
Management Overview (10%)				$147.00
ES&H Overview (10%)				$147.00
Sub Total				$1764.00
LLW Management Cost				$100,000.00
Total				$101764.00

The average cost of recycling scrap metal and other miscellaneous equipment is $750 per cubic meter based on operating experience. Electronic equipment can undergo DSSR for approximately $2,000 per cubic meter. To compute the costs of these items, it was assumed that 50% of the material could be recycled and that the waste costs to characterize and ship the material to the recycling facility were the same costs to ship the waste to the disposal facility. The costs for these items are presented in Tables 3 and 4.

Table 3: Cost for Disposition of Scrap Metal and Miscellaneous Equipment

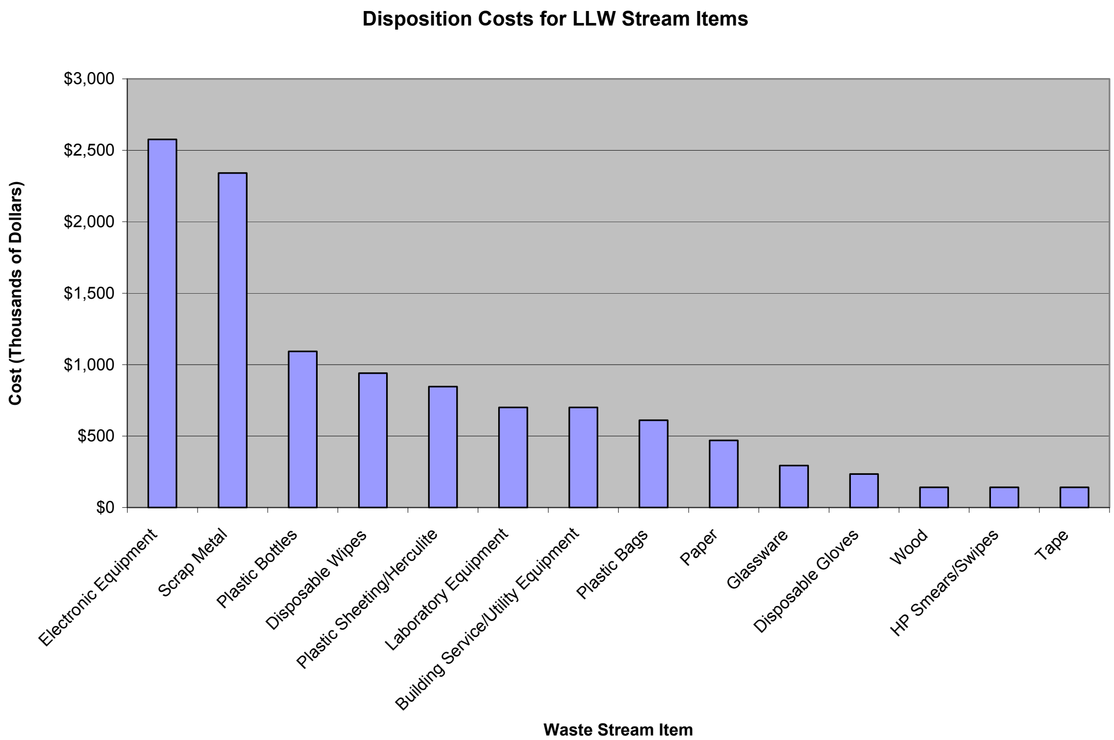
Task	**Hours**	**Labor Cost ($/hr)**	**Volume (m^3)**	**Cost/m^3**
Characterize Waste	8	$75.00	2.7	$222.22
Survey Waste Shipment	4	$75.00	30	$10.00
Load Waste Shipment	4	$75.00	30	$10.00
Transport Waste Shipment	2	$75.00	30	$5.00
SubTotal				$247.22
Management Overview (10%)				$34.72
ES&H Overview (10%)				$34.72
Sub Total				$316.66
LLW Management Cost (50%)				$1834.00
Recycling Cost (50%)				$325.00
Total				$2475.66

Table 4: Cost for Disposition of Electronic Equipment

Task	**Hours**	**Labor Cost ($/hr)**	**Volume (m^3)**	**Cost/m^3**
Characterize Waste	8	$75.00	2.7	$222.22
Survey Waste Shipment	4	$75.00	30	$10.00
Load Waste Shipment	4	$75.00	30	$10.00
Transport Waste Shipment	2	$75.00	30	$5.00
SubTotal				$247.22
Management Overview (10%)				$24.72
ES&H Overview (10%)				$24.72
Sub Total				$296.68
MLLW Management Costs (10%)				$10000.00
LLW Management Cost (40%)				$1467.20
Recycling Cost (50%)				$1000.00
Total				$12763.88

Using these costs, the waste streams depicted in Figures 1 and 2 are now presented in a Pareto Chart (see Figure 3) as a function of cost. The most expensive waste stream is the electronic equipment.

Figure 3


Disposition Costs for LLW Stream Items
Cost (Thousands of Dollars)
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
Electronic Equipment
Scrap Metal
Plastic Bottles
Disposable Wipes
Plastic Sheeting/Herculite
Laboratory Equipment
Building Service/Utility Equipment
Plastic Bags
Paper
Glassware
Disposable Gloves
Wood
HP Smears/Swipes
Tape
Waste Stream Item